An Airborne 94 GHz Cloud Radar for NASA ER−2

(http://rsd.gsfc.nasa.gov/912/crs)

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A 94 GHz (W-band) airborne radar, Cloud Radar System (CRS), has been developed and flown on the NASA ER-2 high altitude (20 km) aircraft, which emulates a satellite view of cloud and precipitation systems. CRS is a fully coherent, polarimeteric Doppler radar. It is capable of detecting clouds and precipitation from the ground surface to upper troposphere. It is especially suited for cirrus cloud studies because of its high sensitivity and fine spatial resolution. The unique combination of CRS with other sensors on board on ER-2, as well as the in situ data from other aircrafts and co-located measurements from ground-based and space-borne instruments provides unprecedented opportunity to study the radiation effects of clouds on the global energy budget. The analysis of CRS data will also improve our knowledge on atmospheric scattering and attenuation at 94 GHz and provides valuable reference for the implementation and algorithm validation of the on going NASA CloudSat program, which will use a 94 GHz space-borne cloud radar for ice cloud detection on the global scale.

CRS collected its first airborne data from the CRYSTAL-FACE experiment. It flew on the NASA ER-2 along with a suite of other remote sensors. Preliminary data analysis shows that CRS functioned well during the flights and has achieved most of the original scientific objectives. Scientific analysis is ongoing, such as combining CRS, ER-2 Doppler Radar (EDOP), Cloud Physics Lidar (CPL) data for cloud ice water content and particle size retrieval.

In addition to operation on ER-2, CRS can also be operated as a ground-based instrument with a larger antenna and higher sensitivity. This makes CRS a high efficient research facility for collecting cloud and precipitation data at 94 GHz.

CRS system specifications

Frequency (GHz)	94.155
IF Frequency (MHz)	59.86
Peak Power (kW)	1.7
Duty Cycle	0.01 max
PRF (kHz)	0.5-10
Pulse Width (μs)	0.25-2.0
Transmit Polarization	V or H
Receive Polarization	V and H
Noise Figure (dB)	7.0
Receiver Bandwidth (MHz)	1, 2, 4
Antenna Beamwidth (deg)	0.6x0.8 (Airborne), 0.3 (Ground-based)
Antenna Gain (dB)	46.4 (Airborne), 55 (Ground-based)
Sensitivity* (dBZe)	-28 (Airborne), -45. (Ground-based)

* R=10 km, δR=150m, 1 second

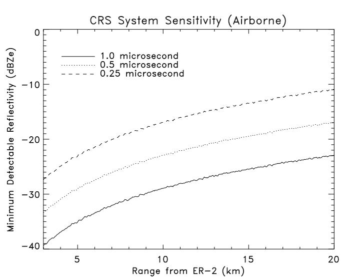

Figure 1. CRS sensitivity estimated from calibrated data.

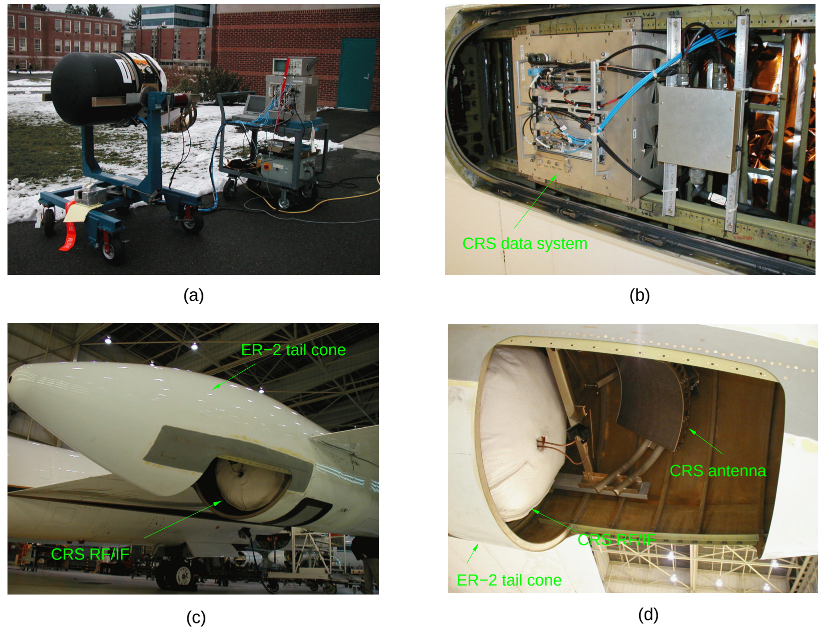

Figure 2. (a) CRS system operated on the ground. (b) Data system install in ER−2 right wing superpod. (c) ER−2 right wing tail cone with CRS RF/IF subsystem inside. (d) Bottom view of CRS antenna.

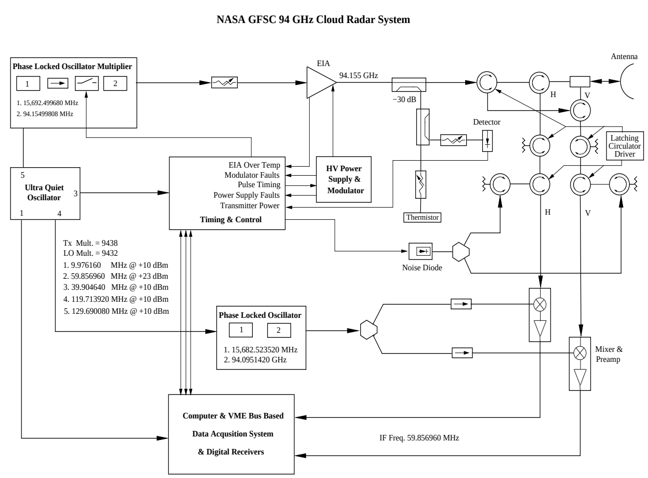

Figure 3. CRS system block diagram.

Key Features

- VME bus data system running VxWorks designed for unattended operation
- Digital receiver, including digital filter and digital I and Q
- Dual PRF algorithm to extend unambiguous Doppler velocity measurements
- Novel designed compact Flat Parabolic Surface (FLAPS) antenna for operation on ER-2
- Pressure canister housing the radar RF/IF subsystem for operation at high altitude

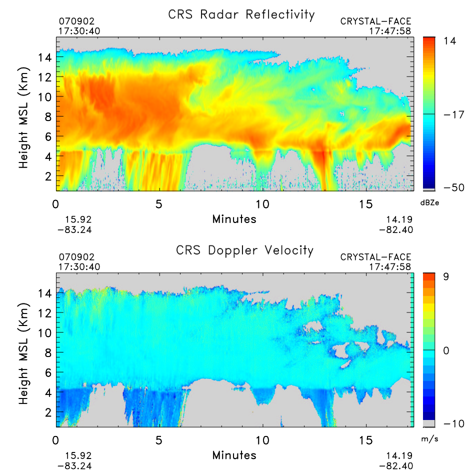

Figure 4. CRS reflectivity and Doppler velocity

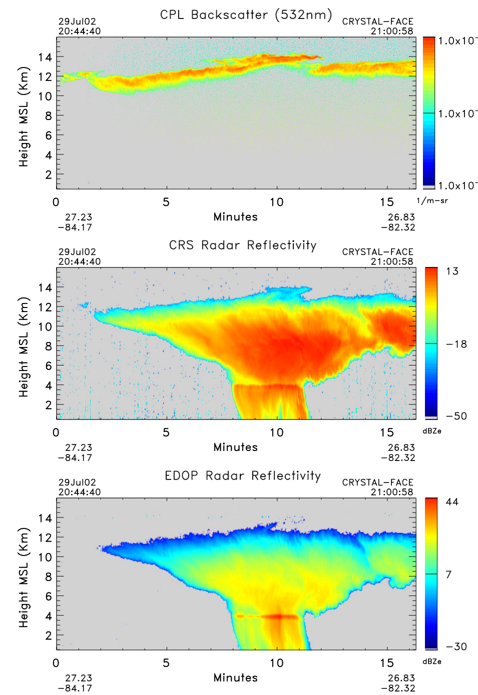

Figure 5. Comparison with EDOP and CPL